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IRON ORES, PRESENT AND FUTURE

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C O N T E N T S

	Page
FOREWARD, by George H. Ashley	1
INTRODUCTION	1
LAKE SUPERIOR IRON ORE RESERVES	2
ALABAMA IRON ORE RESERVES	2
SUPPLY ASSURED	2
FOREIGN IRON ORES	2
SUMMARY	4
PENNSYLVANIA IRON ORE RESOURCES	4
Magnetic Iron Ore Deposits	4
Brown Iron Ore Deposits	5
Fossiliferous Clinton Hematite Deposits	5
Summary	6
SOURCES OF INFORMATION	6

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Foreward: The Geological Survey is often asked, "When will conditions permit reopening the old iron mines of Pennsylvania known not to have been exhausted?" The answer is - When outside sources of high grade, cheaply mined ores, available to Pennsylvania are exhausted. From the facts and figures presented by Mr. Hickok in the following paper it is obvious that these old mines will not be reopened in this generation, and possibly not in several generations. This Survey has made a detailed study of the iron ores of Pennsylvania and has that information on file. It also has a large amount of information on sources of ore in other States and Countries, enough to suggest that, except for ore from the great deposit at Cornwall, Lebanon County, there is likely to be little ore mined in Pennsylvania in the next 50 or possibly 100 years. Facts are stubborn things.

Geo. H. Ashley
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INTRODUCTION

The value of iron ore is determined by its supply and demand just as is the value of any other commodity. Pennsylvania, with its large supply of coking coal and its many blast furnaces, will have a large demand for iron ore for many years to come. Although there is considerable potential iron ore in Pennsylvania nearly the whole of the iron ore supply is imported from other States and iron from foreign countries. Most Pennsylvania iron ore is low grade (carries low percentages of iron) and costly to mine, wherefore it is advantageous to the blast furnace operators in Pennsylvania to bring in from distant points high grade iron ores that can be mined cheaply. At present, the greater part of the supply of iron ore is provided by the Lake Superior mining region and only a small part is imported into the United States from foreign countries (Chile, Cuba, Sweden, North Africa, Brazil, etc.). Before the low grade ores of Pennsylvania become valuable and are extensively used, it is necessary that these high-grade deposits be exhausted or, at least, that the grade of the ore shipped from them decrease materially in iron content.

The iron ore reserves of the Lake Superior region have been reported in a recent newspaper article to be nearly exhausted. It is claimed that this would mean the revival of Pennsylvania iron ore mining. This report is not based on fact as the most conservative of the estimates of Lake Superior iron ore reserves gives them 1,500,000,000 tons of ore, which would supply the iron industry with ore for about 25 years. Less conservative estimates show that the region has 40 or 50 years' supply of iron ore of the present grade, not to mention the supply of low grade iron ore. Even if the Lake Superior deposits should be exhausted, there still remain much larger foreign supplies of iron ore which can be shipped cheaply to the United States sea board and even to the western part of Pennsylvania as return loads in the cars carrying coal to the Atlantic seaboard from the Pittsburgh region.

In the following parts of this article the writer intends to deal first with the supply of iron ore in the Lake Superior and Alabama regions, then with foreign ore deposits and conclude with a brief resume of Pennsylvanian potential iron ore supplies.

LAKE SUPERIOR IRON ORE RESERVES

The Lake Superior iron ore deposits are situated in Minnesota, Wisconsin and Michigan, with by far the largest reserves in the Mesabi Range, in Minnesota. The tax commissions of Minnesota and Michigan each year estimate the reserve tonnages of merchantable ore in the various mines and calculate the totals for the States. In Wisconsin, tax commission figures are not published and estimates of ore reserves are less accurate.

	Tons
Iron ore reserves of Minnesota	1,242,000,000
" " " " Michigan	169,000,000
" " " " Wisconsin	<u>23,000,000</u>
Total reserves	1,434,000,000

This tonnage of iron ore will last for 23 years at the present rate of consumption but if the present increase in consumption continues, it is only sufficient for 23 years. However, there is, from year to year, an increase in the ore reserves caused by the discovery of additional deposits and the extension of old deposits which will somewhat increase the life of the district, probably bringing it up to 30 years or more. Methods of concentration of the Lake Superior ores are also being sought. If any method is found which will cheaply concentrate low grade ore the life of the region will be greatly prolonged.

ALABAMA IRON ORE RESERVES

In the mountains around Birmingham Alabama, there are large deposits of iron ore carrying 35 per cent iron. This low grade ore is valuable because it is located near coking coal and is largely self fluxing. The present production is 5,000,000 tons a year and the reserves are about 1,500,000,000 tons. This will give the district a very long life even if production increases materially. However, due to the low grade of the ore, it seems unlikely that it will be shipped to Pennsylvania in the near future if at all. Therefore Alabama iron ore need not be counted in a study of the future of the Pennsylvania iron ore mining industry.

SUPPLY ASSURED

The domestic iron ore supply of the United States, and of Pennsylvania in particular, is assured for the next 20 years at least. Even after 20 years, however, if no method of iron ore concentration is found which increases the Lake Superior reserves, there will be an abundant supply of foreign iron ore as will be shown in the next section. In fact foreign iron ore has already largely displaced the domestic ore along the Atlantic seaboard, and with a slight increase in the price of Lake Superior ore it may be able to penetrate ^{to} the western part of Pennsylvania and even farther. That the larger iron and steel companies are anticipating such an occurrence can be seen in the fact that they are now acquiring foreign iron ore supplies.

FOREIGN IRON ORES

Figures for foreign supplies of high-grade iron ore are less complete and estimates in years of productivity of any region are difficult to make because of the uncertainty of its future production. Large deposits of high-grade iron

ore are known in Cuba, Chile, Brazil, Venezuela, Newfoundland, Sweden, India, North Africa, China, France, and Russia. Ore from some of these deposits will probably never enter the market in this country either because of home consumption or the distance of the deposits from the sea and the consequent high cost of shipping. Among such deposits are those of France, Russia, and China. Nearly all of the others are available for consumption here and can supply iron ore cheaper than can be done by the high cost mining of the low grade Pennsylvania deposits.

Cuba. The Cuban iron ore deposits are of two types. The first type produces hard ore with a high content of iron. Deposits of this type lie along the southeast coast of Cuba, and as they are nearly exhausted, they are of little importance in iron ore markets of the future. The second type of iron-ore deposit in Cuba is a low grade surface accumulation of iron oxide and hydroxide covering large areas on the eastern end of the island. This ore can be beneficiated and constitutes a very large reserve. Over 2,500,000,000 tons are known to exist. The greater part of the ore is owned by the Bethlehem Steel Company and probably it will be used in the United States. The ore contains nickel and chromium in small quantities. These are detrimental to its use as pig iron but are an aid in making certain kinds of steel. At present very little is mined.

Chile. The deposits in Chile carry high-grade iron ore. They also are operated by the Bethlehem Steel Company and the ore is shipped to the United States through the Panama Canal. Consumption of over one million tons annually is shown by "Mineral Resources of the United States." Estimates of the Chilean reserves are not available.

Brazil. Export of iron ore from Brazil is very small due to poor transportation facilities from the deposits to the sea and to the attitude of the Brazilian government toward the depletion of natural resources. Conservative estimate of the iron ore reserves gives 3,500,000,000 tons as the probable figure, whereas, other estimates run as high as 8,000,000,000 tons. The ore is very desirable because of its high iron and low phosphorus content. Such a gigantic deposit could supply the entire world with iron ore for 50 to 100 years at least.

Venezuela. Venezuela, although producing no iron ore, has large reserves which are accessible to ocean transport. No figures have been compiled for the total iron ore in all the deposits known but exploration work carried on in some of the districts has developed large tonnages of very high-grade iron ore. Although not as large as the Brazilian deposits, the Venezuelan will contribute largely to the world supply of iron ore.

Newfoundland. The Newfoundland deposits have been producing iron ore for many years. These deposits are exceptional in that the iron ore is loaded directly into ocean steamers at the mine mouth. Due to the fact that the ore beds lie under Conception Bay, the reserves cannot be explored by surface drilling, but they are known to be large and are probably limited only by the distance underground to which mining can be carried profitably.

Sweden. The Kirunivarra and other smaller ore deposits of northern Sweden have an annual production of 5,000,000 tons. The ore, which is high in phosphorus, is consumed mostly in Germany but production could readily increase to supply the United States if there was sufficient demand. The reserves of these deposits are very large; they are estimated at 1,150,000,000 tons lying within 1,000 feet of the surface, with still greater tonnages at greater depth.

Asia and Africa. The Indian and North African iron ore deposits are not as large as the foregoing but are capable of operating for many years and producing millions of tons of iron ore for export. The Chinese iron ore deposits are not as large as has been assumed in the past. They are, however, sufficient to supply China and Japan for a long period.

France. The Minette iron ores of France and Luxemburg rank among the largest in the world and although they are of comparatively low grade, their position near the great European coal mines makes them very valuable. They will continue to supply Central Europe with iron ore for many years, but, probably, will never compete in the United States markets.

Russia. The extent of Russian ore deposits is largely a matter of conjecture but it can be assumed that although great in volume and in some cases high in quality they will not be great factors in our market because of the long railroad haul to seaboard of ore from all but a few of the Russian deposits.

SUMMARY

Any shortage of iron ore in American markets in the near future is completely out of the question. Many of the great undeveloped deposits are merely waiting for the investment of capital to bring them a large yearly production, whereas, many others could afford to maintain an equally large production with a very slight increase in the value of iron ore. In addition, there are the great deposits of titaniferous magnetite which are, at present, unproductive, unexplored, and not considered as potential iron ore reserves because of their titanium content. Advances in metallurgical methods may at any time bring such ores into active use, thus increasing greatly the world supply of iron ore.

PENNSYLVANIA IRON ORE RESOURCES

Mining of iron ore has long been an industry in Pennsylvania. Two centuries ago charcoal iron furnaces were operating in the southeastern part of the State, drawing the iron ore from small near by deposits. From this small beginning the iron manufacturing industry of the State has grown steadily until the present and it has good prospects of a continued growth. Although the ore now in use comes largely from outside the State, the presence here of abundant coking coal holds the iron smelting industry because less tonnage of iron ore, than of coal, is used in making iron and steel, so that it is cheaper to transport the iron ore to the coal than visa versa.

Three types of iron ore have been mined in Pennsylvania: magnetic iron ore, brown iron ore, and red hematitic iron ore. The abandonment of the mining of two of these varieties and the great reduction in number of operators in the third came about not through the exhaustion of the ore but because of a number of other causes, the chief of which were the opening up of the very rich Lake Superior mines and the increasing cost of mining iron ore in the small Pennsylvania mines. The Pennsylvania iron ore deposits will be discussed briefly here under headings corresponding to the three types of ore, with regard to present and future use. No resume' is attempted of past mining.

Magnetic Iron Ore Deposits

The only iron ore mined at present in Pennsylvania occurs in deposits of this type. Although the iron content of the magnetic ore is low, averaging 35 to 40 per cent iron, the ore is profitable to mine because it can be beneficiated very cheaply. The process of concentration aids the ore, also, as it reduces the undesirably high sulphur content and recovers nearly all the copper which the ore contains. One mine, at Cornwall, Lebanon County, has produced an average for the last 10 years of 900,000 tons of ore annually. This is the only iron mine operating in Pennsylvania.

Deposits of magnetic iron ore are associated with diabase intrusives throughout the Triassic red lands of southeastern Pennsylvania. An advance in the price of iron ore is necessary to make profitable the mining of small deposits of this ore so that extensive operations in any of the existing mines or known deposits except the one at Cornwall will not take place for many years. However, the discovery of a new large deposit may occur at any time and if it is large enough to warrant the erection of a concentrating plant near by it can be worked profitably at present. The probability of such a discovery seems remote, however, as all the most likely spots in the Triassic area have been prospected thoroughly by mining companies. For geologic data on the location of favorable places for deposits of this type see U. S. Geol. Survey, Bulletin 359, by A. C. Spencer, Deposits of the Cornwall Type in Pennsylvania, 1908.

Brown Iron Ore Deposits

Although brown iron ore was once mined more extensively in Pennsylvania than any other kind, none is mined at present. The drop in production of this type of ore is only partly due to competition from the ores brought into the State. It is, in part, to be ascribed to the exhaustion of the larger, better situated brown ore bodies, leaving only small isolated deposits which, in many cases, have been stripped of their high grade material.

The future prospects of a revival of brown iron ore mining are very poor, due to the nature of the deposits themselves as well as to the large reserves of high grade iron ore available for shipment into Pennsylvania. The brown ore deposits are accumulations of iron oxides at or near the surface and, consequently, the finding of new large ore bodies is so unlikely and the cost of mining the known small ore bodies so high that there will never be a general revival of the brown iron ore industry.

Fossiliferous Clinton Hematite Deposits.

At the peak of Pennsylvania iron mining, ore was extracted from several horizons in the Clinton formation of Silurian age. Nearly all the ore used came from small local enrichments that have taken place in some of the horizons. In only a few cases was the unweathered and unenriched ore mined. The soft weathered material carries about 45 per cent iron whereas, the hard unaltered sedimentary beds forming the ore horizons carry only 25 to 30 per cent iron. As the ore beds themselves are only about 1 to $1\frac{1}{2}$ feet thick, mining costs would be very high and it will be many years before any hard ore can be mined profitably. The soft ore, carrying more iron, is restricted in occurrence and the deposits are so small that they will not lend themselves to the installation of mining machinery and, therefore, they will not be mined except in connection with larger amounts of hard ore unless they are destined for use in some small industry located near the deposit.

Clinton iron ores occur and are mined in Alabama, Tennessee, and New York. Favorable conditions, which do not occur in Pennsylvania, make this possible. In Alabama and Tennessee the ore beds are much thicker and the grade of the ore (35 per cent iron) is higher than in Pennsylvania. These facts and the great distance of the district from rich ores make the deposits valuable. In New York the beds are thick (3 to 4 feet), the grade of the ore (40 to 45 per cent iron) is higher than in Pennsylvania and the altitude of the beds is nearly horizontal, which brings large quantities of ore near the surface. This combination of circumstances, all favorable to cheap production of a fairly high grade of ore, makes it possible to mine the Clinton iron ore in New York. However, in Pennsylvania conditions are less favorable. Not only is the grade of the iron ore low, but the

beds of ore are so thin that much rock besides the ore would have to be mined. The altitude of the ore beds is so steep, also, that only small amounts of ore occur near the surface.

Summary

The combination of the disadvantages of mining the known Pennsylvania iron ore deposits and the abundant supply of high grade iron ore available for import into the State makes a revival of Pennsylvanian iron ore mining extremely unlikely for many decades to come. This does not mean that new deposits of iron ore may not be discovered, but that the Pennsylvania iron ore resources are of such a nature that they cannot be worked under the conditions of supply and demand which exist at present and appear probable for the future.

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